Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Iridium Constellation LLC	)	File Nos.: SAT-MOD-20131227-00148
	)	SAT-AMD-20151022-00074
Application for Modification of License to Authorize a Second-Generation NGSO MSS Constellation	)	Call Sign: S2110

ORDER AND AUTHORIZATION

Adopted: August 1, 2016 **Released: August 1, 2016**

By the Chief, Satellite Division, International Bureau; and Acting Chief, Policy and Rules Division, Office of Engineering and Technology:

I. INTRODUCTION

1. By this Order, we authorize Iridium Constellation LLC (Iridium) to construct, deploy, and operate non-geostationary-satellite orbit (NGSO) space stations to continue and enhance its provision of mobile-satellite service (MSS) and aeronautical mobile-satellite (route) service (AMS(R)S). This authorization will allow Iridium to continue to provide mobile voice and data services to end users on a network with improved voice quality and enhanced data transmission speeds.

II. BACKGROUND

2. *Current constellation*. Iridium operates an NGSO satellite constellation capable of providing MSS anywhere in the world. Originally licensed in 1995,[1] the Iridium system is authorized for 66 service satellites, plus any co-located satellites,[2] and up to 14 in-orbit spares.[3] The constellation operates in a near-circular Earth orbit at an altitude of 778 kilometers,[4] and is arranged in six orbital

[1] *Application of Motorola Satellite Communications, Inc. for Authority to Construct, Launch, and Operate a Low Earth Orbit Satellite System in the 1616–1626.5 MHz Band*, Order and Authorization, 10 FCC Rcd 2268 (IB 1995) (*First Generation License*), *corrected*, 10 FCC Rcd 3925 (IB 1995), https://apps.fcc.gov/edocs_public/attachmatch/DOC-54363A1.pdf, *affirmed in part and modified*, *Applications of Motorola Satellite Communications, Inc., et al., for Authority to Construct, Launch, and Operate, Low Earth Orbit Satellite Systems to Provide Mobile Satellite Services in the 1610-1626.5 MHz/2483.5-2500 MHz Bands*, Memorandum Opinion and Order, 11 FCC Rcd 18502 (1996), https://apps.fcc.gov/edocs_public/attachmatch/FCC-96-279A1.pdf (*Reconsideration Order*).

[2] *Iridium Constellation LLC*, Stamp Grant, File No. SAT-MOD-20120813-00128 (granted Jan. 30, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1034020. Iridium may co-locate additional satellites with those in its 66-satellite mission constellation that become partially impaired. Two co-located satellites operate as the functional equivalent of one satellite.

[3] *Application of Space System License, Inc. for Modification of License for Authority to Launch and Operate a Low Earth Orbit Satellite System in the 1616-1626.5 MHz Band*, Order and Authorization, 14 FCC Rcd 9829 (IB, Sat. Div. 1999), http://www.fcc.gov/Bureaus/International/Orders/1999/da991254.txt.

[4] Iridium Constellation LLC, Application for Minor Modification, Appendix A at A-2, File No. SAT-MOD-20080701-00140 (filed July 1, 2008), http://licensing.fcc.gov/myibfs/download.do?attachment_key=-150576. The nominal altitude is 780 km. *See First Generation License*, 10 FCC Rcd at 2268, para. 2.

planes at an inclination of 86.4 degrees.[5] Iridium satellites use an array of spot beams to communicate with subscriber units. They connect to "gateway" earth stations through feeder links.[6] Within the constellation, adjacent satellites communicate with each other via inter-satellite links.[7]

3. The Iridium constellation is assigned frequencies in the L-band, the Ka-band, and the 23.18-23.38 GHz band.[8] Service links are authorized in the 1617.775-1626.5 MHz band for transmission in both directions between mobile earth stations and Iridium satellites.[9] Communication between satellites is authorized in the 23.18-23.38 GHz band.[10] Feeder links and telemetry, tracking, and command (TT&C) operations are authorized in the 19.4-19.6 GHz (space-to-Earth) and 29.1-29.3 GHz (Earth-to-space) bands.[11] Iridium shares the 29.25-29.3 GHz feeder uplink band on a co-primary basis with geostationary-satellite orbit (GSO) space stations in the fixed-satellite service (FSS).[12]

4. As a result of a license modification granted in 2013, Iridium is also authorized to provide AMS(R)S in the 1618.725-1626.5 MHz band to remote, oceanic and polar regions.[13] AMS(R)S is an aeronautical mobile-satellite service reserved for communications relating to safety and regularity of flights, primarily along national or international civil air routes.[14] On May 22, 2014, we granted an

[5] *First Generation License*, 10 FCC Rcd at 2268, para. 2.

[6] *Id.* In the NGSO MSS, fixed feeder-link earth stations are needed to complete the transmission paths with mobile user terminals, process the information being transmitted, and interconnect the NGSO MSS system with terrestrial communications networks and with other user transceivers. Feeder-link earth stations that distribute information to, and receive information from, terrestrial telecommunication networks, e.g., the public switched telephone network and the Internet, are known as gateways. Iridium commercial traffic is routed through a central gateway located in Tempe, Arizona (Call Sign E960131). Comments of Iridium Constellation LLC, File No. SES-MFS-20111104-01314, at 2 (filed Dec. 16, 2011), http://licensing.fcc.gov/myibfs/download.do?attachment_key=930008.

[7] *First Generation License*, 10 FCC Rcd at 2268, para. 2.

[8] For purposes of this Order and Authorization, "L-band" means the 1610-1626.5 MHz frequency band, and "Ka-band" means the 17.7-20.2 GHz and 27.5-30.0 GHz frequency bands.

[9] *Iridium Constellation LLC et al., Modification of Authority to Operate a Mobile Satellite System in the 1.6 GHz Frequency Band*, Order of Modifications, 23 FCC Rcd 15207, 15222, para. 46 (2008), https://apps.fcc.gov/edocs_public/attachmatch/FCC-08-248A1.pdf. Iridium provides MSS on an exclusive basis in the 1618.725-1626.5 MHz band, and shares the 1617.775-1618.725 MHz band with the Globalstar NGSO MSS system. *Id.* MSS uplink operations in the 1617.775-1626.5 MHz band are allocated on a primary basis worldwide. MSS downlinks in that band are secondary to other services. *Id.*; *see also* 47 C.F.R. § 2.106 (Table of Frequency Allocations).

[10] *Reconsideration Order*, 11 FCC Rcd at 18516, para. 36.

[11] *See Application of Motorola Satellite Communications, Inc. for Modification of License*, Order and Authorization, 11 FCC Rcd 13952, 13954-55, para. 7 (IB 1996), https://apps.fcc.gov/edocs_public/attachmatch/DA-96-1789A1.pdf.

[12] *See Rulemaking to Amend Parts 1, 2, 21, and 25 to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, First Report and Order, 11 FCC Rcd 19005, 19024, para. 42, 19034-35, paras. 72-74 (1996), http://apps.fcc.gov/ecfs/comment/view?id=166582. This band is available for blanket licensing of GSO FSS earth stations. 47 C.F.R. § 25.115(e); *Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use*, Second Order on Reconsideration, 17 FCC Rcd 24248, 24259-60, para. 24 (2002), https://apps.fcc.gov/edocs_public/attachmatch/FCC-02-317A1.pdf.

[13] *Iridium Constellation LLC, For Authority to Modify License For A Low Earth Orbit Mobile Satellite System*, Memorandum Opinion and Order, 28 FCC Rcd 964 (IB 2013), https://apps.fcc.gov/edocs_public/attachmatch/DA-13-141A1_Rcd.pdf.

[14] 47 C.F.R. § 2.1.

extension of the license term for Iridium's first-generation satellites, to January 31, 2018, based on Iridium's description of the planned deployment of its second-generation satellites.[15]

5. *Modification application*. On December 27, 2013, Iridium filed an application to modify its NGSO MSS license to operate a second-generation satellite system.[16] Iridium proposes to replace its existing constellation with a new constellation using the same orbital parameters, providing the same global coverage, and transmitting on the same frequency bands.[17] Like Iridium's first-generation satellites, the new satellites will be capable of operating in the entire 1616-1626.5 MHz band; however, Iridium here requests no change from the operating frequencies specified for its first-generation satellites.[18] To provide continuous service during the transition, Iridium proposes to replace its existing satellites one-for-one with new satellites as they are launched.[19] Iridium expects to have entirely replaced its first-generation constellation shortly after completing a series of launches.[20] Iridium also requests authority for up to 15 second-generation in-orbit spare satellites,[21] and to reserve the option to retain some first-generation satellites as potential spares.[22]

6. Iridium states that its second-generation satellites will also be equipped to track ships and aircraft. Aircraft tracking will be accomplished through an Automatic Dependent Surveillance–Broadcast (ADS-B) receiver as part of a joint venture with Aireon LLC.[23] The receiver will receive Extended Squitter ADS-B messages from aircraft on the 1090 MHz center frequency, and information regarding those messages will be relayed through the Iridium inter-satellite links and feeder downlinks to earth stations.[24] The ADS-B information will then be routed to air traffic control authorities, thereby providing a global, satellite-based aviation monitoring service.

7. Iridium has also contracted with Harris Corporation to include a receiver for Automatic Identification System (AIS) messages on up to 65 of its second-generation satellites. AIS is a shipboard broadcast system that transmits a marine vessel's identification and position to aid in navigation and

[15] *Iridium Constellation LLC*, Stamp Grant, File No. SAT-MOD-20101001-00207 (granted in part May 22, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1048067.

[16] Iridium Constellation LLC, Application for Modification of NGSO Authorization to Launch and Operate Replacement Satellites, File No. SAT-MOD-20131227-00148 (filed Dec. 27, 2013) (Second Generation Application). The modification application was amended on October 22, 2015, in File No. SAT-AMD-20151022-00074, as noted below. Iridium's amended application can be accessed online through the International Bureau Filing System, http://licensing.fcc.gov/myibfs.

[17] Second Generation Application, Engineering Statement at 5-6, Narrative at 3. As described below, Iridium requests authority for additional receive frequencies not authorized for its first-generation satellites.

[18] Second Generation Application, Narrative at 3. Iridium has pending before the Commission a petition for rulemaking regarding expansion of the operating frequency range of its MSS links to 1616-1626.5 MHz. Petition for Rulemaking of Iridium Constellation LLC, RM-11697, http://apps.fcc.gov/ecfs/proceeding/view?name=RM-11697. Iridium's requests in that proceeding will be addressed separately.

[19] Second Generation Application, Engineering Statement at 8-9.

[20] *Id.*, Engineering Statement at 9 (providing a schedule, as of the date the application was filed, with a final launch in 2017).

[21] *Id.*, Engineering Statement at 2.

[22] *Id.*, Engineering Statement at 9. This Order is based on a planned one-for-one substitution of first-generation satellites by second-generation satellites, but does not preclude Iridium seeking authorization at a later date to retain some first-generation satellites as spares.

[23] *Id.*, Exhibit D.

[24] *Id.* at 2; Opposition of Iridium Constellation LLC at 9-10 (filed Apr. 15, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1043165 (Iridium Opposition).

maritime safety. The satellite AIS receiver will receive AIS messages within the 156.0125-162.0375 MHz band and, as with the 1090 MHz Extended Squitter ADS-B receiver, information regarding those messages will be relayed through the Iridium inter-satellite links and feeder downlinks. On October 22, 2015, Iridium filed an amendment to its modification application with additional information regarding the AIS receiver.[25]

8. Iridium requests waiver of several Commission rules in its Second Generation Application.[26] First, Iridium seeks waiver of section 25.210(i)(1), which requires that space station antennas in the FSS be designed to provide a cross-polarization isolation of 30 dB within their primary coverage area.[27] Second, Iridium requests waiver of section 25.202(g) to allow TT&C operations throughout its assigned Ka-band feeder-link frequencies, rather than solely at the band edges.[28] Third, Iridium seeks waivers of sections 25.114(d)(14)(ii) and 25.283(c) to maintain residual energy sources on board its satellites at their at end-of-life.[29] Finally, Iridium states that the design of its second-generation satellites, which use on-board processors and regenerative payloads, renders inapplicable certain technical information requested in section 25.114(c)(4)(vi) and (vii).[30] Iridium requests waiver of those rules to the extent necessary.

9. *Comments*. On February 28, 2014, we placed Iridium's Second Generation Application on public notice.[31] In response, three GSO FSS space station operators commented on the application. Inmarsat Inc. (Inmarsat) filed a petition to dismiss, deny, or hold in abeyance Iridium's application.[32] SES Americom, Inc. (SES) filed a comment.[33] ViaSat, Inc. (ViaSat) responded to Inmarsat's and SES's initial pleadings.[34]

10. Inmarsat, SES, and ViaSat ask that we require Iridium to demonstrate that its second-

[25] Iridium Constellation LLC, Amendment to Application for Modification of NGSO Authorization to Launch and Operate Replacement Satellites, File No. SAT-AMD-20151022-00074 (filed Oct. 22, 2015) (Second Generation Application Amendment).

[26] Iridium requested waiver of additional rules in its Second Generation Application Amendment. These requests are unopposed and discussed below.

[27] Second Generation Application, Narrative at 12-13; 47 C.F.R. § 25.210(i)(1). As noted below, this requirement is applicable to Iridium's feeder-link operations, which are performed using frequencies allocated to the FSS.

[28] Second Generation Application, Narrative at 15-16. Section 25.202(g) requires TT&C functions to be conducted "at either or both edges of the allocated band(s)." 47 C.F.R. § 25.202(g).

[29] Second Generation Application, Narrative at 13-15. Section 25.114(d)(14)(ii) requires a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy remaining at end-of-life. 47 C.F.R. § 25.114(d)(14)(ii). Section 25.283(c) requires that all stored energy sources be discharged at the satellite end-of-life. 47 C.F.R. § 25.283(c).

[30] Second Generation Application, Narrative at 11-12; 47 C.F.R. § 25.114(c)(4)(vi), (vii).

[31] *Policy Branch Information, Satellite Space Applications Accepted for Filing*, Public Notice, Report No. SAT-00999 (rel. Feb. 28, 2014), https://apps.fcc.gov/edocs_public/attachmatch/DOC-325833A1.pdf. The amendment was also placed on public notice. *Policy Branch Information, Satellite Space Applications Accepted for Filing*, Public Notice, Report No. SAT-01116 (rel. Nov. 6, 2015), https://apps.fcc.gov/edocs_public/attachmatch/DOC-336234A1.pdf. No comments were filed on the amendment.

[32] Petition to Dismiss, Deny or Hold in Abeyance of Inmarsat Inc. (filed Mar. 31, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1041101 (Inmarsat Petition).

[33] Comments of SES Americom, Inc. (filed Mar. 31, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1041116 (SES Comments).

[34] Response of ViaSat, Inc. (filed Apr. 15, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1043235 (ViaSat Response).

generation system can share the 29.25-29.3 GHz band with GSO FSS operations.[35] SES argues this demonstration is required by section 25.258(c).[36] Inmarsat and ViaSat also argue that Iridium has not justified its requested waiver of the 30 dB cross-polarization isolation requirement in section 25.210(i)(1).[37] SES suggests that any waiver of sections 25.210(i)(1) or 25.202(g) should be granted only with certain conditions.[38] Finally, both Inmarsat and ViaSat ask that Iridium provide additional information regarding its 1090 MHz Extended Squitter ADS-B receiver.[39]

11. Iridium filed an opposition to the initial pleadings of Inmarsat and SES and replied to ViaSat.[40] Inmarsat and SES replied to Iridium in turn.[41] In its reply, Inmarsat specifies that Iridium should not be granted heightened interference protection for its Ka-band feeder links if they are used to support the 1090 MHz Extended Squitter ADS-B receiver.[42] In addition, the Committee on Radio Astronomy Frequencies (CRAF) and the National Radio Astronomy Observatory (NRAO) filed letters with the Commission regarding potential interference by Iridium out-of-band emissions from its second-generation constellation into radio astronomy service (RAS) observations in the 1610.6-1613.8 MHz band.[43] Finally, Ligado Networks LLC (Ligado) filed a request to hold in abeyance the Iridium application.[44] In separate proceedings, Iridium has contended that Ligado's proposed operation of an ancillary terrestrial component to its mobile-satellite service network will harm Iridium's second-generation operations. Ligado asks that we delay action on Iridium's application pending further exploration of the compatibility of the two systems.

12. *Part 25 Second Report and Order*. After the closing of the comment periods in this proceeding, the Commission adopted an Order comprehensively revising part 25 of its rules.[45] Among the revisions, the Commission eliminated or relaxed several requirements from which Iridium seeks

[35] Inmarsat Petition at 3-4, 6; SES Comments at 2; ViaSat Response at 1-2.

[36] SES Comments at 2. Section 25.258 addresses sharing between NGSO MSS feeder-link stations and GSO FSS services in the 29.25-29.5 GHz band. 47 C.F.R. § 25.258.

[37] Inmarsat Petition at 4-5; ViaSat Response at 2-3.

[38] SES Comments at 2-4.

[39] Inmarsat Petition at 5-6; ViaSat Response at 3-5.

[40] Iridium Opposition; Reply of Iridium Constellation LLC (filed Apr. 25, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1044378 (Iridium Reply). Iridium argues that the ViaSat Response is, in fact, a late-filed opposition to its Second Generation Application. Iridium Reply at 1 n.2; *see also* 47 C.F.R. § 25.154(a). Assuming *arguendo* this were the case, we would still be able to consider the ViaSat Response as an informal objection under section 25.154(b), and would do so here. *See* 47 C.F.R. § 25.154(b); *News Corp. and The DIRECTV Group, Inc., Transferors, and Liberty Media Corp., Transferee, For Authority to Transfer Control*, Memorandum Opinion and Order, 23 FCC Rcd 3265, 3329 n.447 (2008), https://apps.fcc.gov/edocs_public/attachmatch/FCC-08-66A1.pdf.

[41] Reply to Opposition to Petition to Dismiss, Deny or Hold in Abeyance of Inmarsat Inc. (filed Apr. 25, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1044372 (Inmarsat Reply); Reply of SES Americom, Inc. (filed Apr. 25, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1044364 (SES Reply).

[42] Inmarsat Reply at 6-7.

[43] Letter from Dr. Hans van der Marel, CRAF Chair, to Mindel De La Torre, Chief, International Bureau (filed July 11, 2014), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1053906; Letter from Harvey S. Liszt, Scientist and Spectrum Manager, National Radio Astronomy Observatory, to the Federal Communications Commission (filed Apr. 29, 2015), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1087482.

[44] Request to Hold in Abeyance of Ligado Networks LLC (filed July 20, 2016), http://licensing.fcc.gov/myibfs/download.do?attachment_key=1143933.

[45] *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, Second Report and Order, 30 FCC Rcd 14713 (2015), https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-167A1_Rcd.pdf.

waivers. Because these rule changes are not yet in effect, we address the Commission's decisions in the context of specific waiver requests, discussed below.

III. DISCUSSION

13. For the reasons discussed below, we grant Iridium's application for a second-generation NGSO MSS constellation, subject to conditions. In doing so, we decline to require the sharing demonstration for the 29.25-29.3 GHz band requested by GSO FSS commenters.

A. Sharing Analysis for the 29.25-29.3 GHz Band

14. Inmarsat, SES, and ViaSat request a demonstration from Iridium that its second-generation satellite system will be compatible with co-primary GSO FSS operations in the 29.25-29.3 GHz band.[46] Inmarsat contends that such a demonstration is important given Iridium's request for waiver of the cross-polarization isolation requirement in section 25.210(i)(1), which Inmarsat states can facilitate sharing.[47] SES argues a sharing demonstration is required based on the "plain language" of section 25.258(c).[48] ViaSat supports the calls for a sharing demonstration.[49] In response, Iridium states that it has provided all the information required concerning its proposed Ka-band use.[50] Iridium notes that feeder-link earth stations are already authorized in the 29.25-29.3 GHz band for communication with its current satellites.[51] Iridium states that it seeks to continue this use with its new satellites without additional interference protection,[52] and under existing coordination agreements.[53]

15. We decline to require the requested sharing demonstration. The International Bureau has interpreted section 25.258(c) as an obligation on earth station applicants when seeking authority to transmit in the 29.25-29.3 GHz band. Accordingly, the Bureau has declined to require such sharing demonstrations when addressing uplink reception in a space station authorization.[54] We act consistent with this precedent. Further, we note that Iridium Satellite LLC, the direct owner of Iridium,[55] holds

[46] Inmarsat Petition at 3-4, 6; Inmarsat Reply at 3-4; SES Comments at 2; SES Reply at 3-5; ViaSat Response at 1-2.

[47] Inmarsat Petition at 3-4; Inmarsat Reply at 4-5; *see also* 47 C.F.R. § 25.210(i)(1).

[48] SES Reply at 3; *see also* SES Comments at 2; SES Reply at 3-5. Section 25.258(c) provides that "[a]pplicants for authority to use the 29.25-29.5 GHz band for NGSO MSS feeder uplinks will have to demonstrate that their systems can share with GSO FSS and NGSO MSS systems that have been authorized for operation in that band." 47 C.F.R. § 25.258(c).

[49] ViaSat Response at 1-2.

[50] Iridium Opposition at 3-5; Iridium Reply at 2.

[51] Iridium Opposition at 5.

[52] *Id.*

[53] *Id.* at 4; Second Generation Application, Engineering Statement at 45.

[54] *See, e.g.*, *Application of the Boeing Company Concerning Use of the 1990-2025/2165-2200 MHz and Associated Frequency Bands for a Mobile-Satellite System*, Order and Authorization, 16 FCC Rcd 13691, 13697-98, para. 16 (IB 2001), https://apps.fcc.gov/edocs_public/attachmatch/DA-01-1631A1.pdf; *Application of Iridium LLC Concerning Use of the 1990-2025/2165-2200 MHz and Associated Frequency Bands for a Mobile-Satellite System, Iridium LLC*, Order and Authorization, 16 FCC Rcd 13778, 13782-83, para. 11 (IB 2001), https://apps.fcc.gov/edocs_public/attachmatch/DA-01-1636A1.pdf (both stating that a sharing demonstration under section 25.258 would be required in an earth station application for uplink transmitting authority, not in an NGSO MSS space station application).

[55] *See* Iridium Satellite LLC, Application for *Pro Forma* Transfer of Control, Attachment 2, File No. SES-T/C-20101001-01273; *see also Iridium Holdings LLC and Iridium Carrier Holdings LLC, Transferors, and GHL Acquisition Corp., Transferee, Applications for Consent to Transfer Control of Iridium Carrier Services LLC, Iridium Satellite LLC, and Iridium Constellation LLC*, Memorandum Opinion and Order and Declaratory Ruling, 24

(continued….)

separate authorizations for feeder-link earth stations in the 29.25-29.3 GHz band.[56] It provided demonstrations required under section 25.258(c) in earth station applications.[57] Iridium indicates that its second-generation satellites will operate with the same feeder-link stations authorized to transmit to its current satellites.[58] To the extent that modification of the radiofrequency operations of the existing stations is necessary to communicate with second-generation Iridium satellites, those stations must include in any modification application appropriate showings, including under section 25.258(c), for any proposed modified operations.[59] We address Iridium's request for waiver of section 25.210(i)(1) in Section III.E below.

B. Automatic Identification System Receiver

16. Iridium proposes to include an AIS receiver on up to 65 of its second-generation satellites.[60] AIS is an international maritime navigation safety communications system through which marine vessels automatically transmit navigational data to appropriately equipped shore stations, other ships, and aircraft.[61] The U.S. Coast Guard utilizes AIS for maritime domain awareness.[62] Iridium proposes to receive AIS messages within the 156.0125-162.0375 MHz maritime very high frequency (VHF) band and to transmit the information through its inter-satellite links in the 23.18-23.38 GHz band and its feeder downlinks in the 19.4-19.6 GHz band.[63] Command and control of the receiver would be

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FCC Rcd 10725, 10726, para. 3, 10751, Appendix B (IB 2009), https://apps.fcc.gov/edocs_public/attachmatch/DA-09-1809A1_Rcd.pdf.

[56] *See* Iridium Satellite LLC, File No. SES-LIC-20051010-01392 (granted Feb. 9, 2006) (Call Sign E050282), http://licensing.fcc.gov/myibfs/displayLicense.do?filingKey=-94553; Iridium Satellite LLC, File Nos. SES-LIC-20060804-01311, SES-AMD-20070309-00333 (granted Mar. 29, 2007) (Call Sign E060300), http://licensing.fcc.gov/myibfs/displayLicense.do?filingKey=-112882; Iridium Satellite LLC, File Nos. SES-MOD-20060907-01680, SES-AMD-20070309-00334 (granted Mar. 29, 2007) (Call Sign E960131), http://licensing.fcc.gov/myibfs/displayLicense.do?filingKey=-115859.

[57] *See* Iridium Satellite LLC, File No. SES-AMD-20070309-00333; Iridium Satellite LLC, File No. SES-AMD-20070309-00334.

[58] Iridium Opposition at 5.

[59] 47 C.F.R. § 25.258(c); *see also* 47 C.F.R. § 25.203(h), (k).

[60] Second Generation Application Amendment at 1 n.4.

[61] *See* 47 C.F.R. § 80.5 (defining AIS). For more information on AIS, see WT Docket No. 04-344 (amending the Commission's rules regarding maritime Automatic Identification Systems).

[62] *Amendment Regarding Maritime Automatic Identification Systems*, Report and Order, 21 FCC Rcd 8892, 8894-95, para. 4 (2006), https://apps.fcc.gov/edocs_public/attachmatch/FCC-06-108A1.pdf. AIS base stations are operated solely by Federal Government entities. *Amendment Regarding Maritime Automatic Identification Systems*, Second Report and Order, 23 FCC Rcd 13711, 13726-27, paras. 25-26 (2006), https://apps.fcc.gov/edocs_public/attachmatch/FCC-08-208A1.pdf.

[63] Second Generation Application Amendment at 1-2 & n.5. Specifically, Iridium proposes to operate using AIS signals in eight 25 kHz channels with the following center frequencies:

161.975 MHz (AIS 1);

162.025 MHz (AIS 2);

156.775 MHz (AIS 3);

156.825 MHz (AIS 4);

161.950 MHz (Application Specific Messages (ASM) 1);

162.000 MHz (ASM 2);

156.525 MHz (Digital Selective Calling (DSC-R)); and

(continued….)

accomplished through Iridium TT&C operations in the 29.1-29.3 GHz uplink band.[64]

17. In the United States, the Commission has allocated the AIS 1 (161.9625-161.9875 MHz) and AIS 2 (162.0125-162.0375 MHz) bands to the MSS (Earth-to-space) on a co-primary basis for reception of AIS messages.[65] The Commission has also proposed to allocate the long-range AIS 3 (156.7625-156.7875 MHz) and AIS 4 (156.8125-156.8375 MHz) bands to the MSS (Earth-to-space) on a primary basis for AIS operations.[66] The Commission has not adopted or proposed MSS allocations for the four other VHF frequencies with which Iridium is proposing to operate.

18. Internationally, the AIS 1, AIS 2, AIS 3, and AIS 4 bands are all allocated to the MSS (Earth-to-space) on a co-primary basis in Region 2 and on a secondary basis in Regions 1 and 3.[67] There are no allocations, international or domestic, to the MSS in the 161.950 MHz (ASM 1),[68] 162.000 MHz (ASM 2), 156.525 MHz (DSC-R),[69] or 156.8 MHz maritime mobile distress channels also requested by Iridium.

19. Iridium requests waivers of several rules to the extent necessary to authorize its proposed operations using VHF frequencies.[70] Specifically, Iridium requests a waiver of the Table of Frequency Allocations, section 2.106, to permit operations in bands not allocated internationally and/or domestically for its requested operations. Iridium also seeks waiver of section 25.112(a)(3), which states that an application will be considered defective if it requests authority to operate a space station in a frequency band not allocated internationally for such operations.[71] In addition, Iridium states that certain default service rules, in section 25.287 and paragraphs (f) and (i) of section 25.210, are inappropriate to apply to its VHF receiver and seeks waivers of these rules to the extent necessary.[72]

(Continued from previous page)
156.8 MHz maritime mobile distress.

[64] October 31, 2014 Supplement at 2.

[65] 47 C.F.R. § 2.106, footnotes 5.228C, US52. Footnote US228 to the U.S. Table of Frequency Allocations provides that non-Federal non-AIS stations may continue to operate in the 161.9625-161.9875 MHz band for varying lengths of time. 47 C.F.R. § 2.106, footnote US228.

[66] *Amendment of Parts 1, 2, 15, 25, 27, 74, 78, 80, 87, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2007) (WRC-07), Other Allocation Issues, And Related Rule Updates et al.*, Report and Order, Order, and Notice of Proposed Rulemaking, 30 FCC Rcd 4183, 4254-55, paras. 202-05 (2015), https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-50A1_Rcd.pdf.

[67] 47 C.F.R. § 2.106, footnotes 5.228, 5.228C, 5.228F.

[68] AIS messages where the data content is defined by the application are application specific messages. Recommendation ITU-R M.1371-5 (02/2014), *Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile frequency band*, Annex 5, https://www.itu.int/rec/R-REC-M.1371/en.

[69] DSC is an internationally approved system for automatically contacting vessels on medium frequency, high frequency, and VHF bands. It allows mariners to send an automatically formatted distress alert instantly to the Coast Guard or other rescue authority anywhere in the world. DSC also allows mariners to initiate or receive distress, urgency, safety and routine radiotelephone calls to or from any similarly equipped vessel or shore station, without requiring either party to be near a radio loudspeaker. It allows users to "direct dial" and "ring" other maritime radio stations.

[70] We address Iridium's requests for waivers of sections 25.114(c)(4)(vi)(B), 25.164, and 25.165, in connection with its AIS payload, below.

[71] 47 C.F.R. § 25.112(a)(3).

[72] Second Generation Application Amendment at 12-13.

20. We may waive the Commission's rules for good cause shown.[73] Waiver is appropriate where the particular facts make strict compliance inconsistent with the public interest.[74] In making this determination, we may take into account considerations of hardship, equity, or more effective implementation of overall policy on an individual basis.[75] Waiver is therefore appropriate if special circumstances warrant a deviation from the general rule and such deviation will serve the public interest.[76] As noted above, only the AIS 1 and AIS 2 channels are currently allocated to the MSS in the U.S. Table of Frequency Allocations. The remaining use of frequencies Iridium requests for MSS (Earth-to-space) reception is therefore not in accordance with the U.S. Table of Frequency Allocations.

21. We waive section 2.102(a), on our own motion,[77] and section 2.106, as requested, to permit Iridium's proposed MSS (Earth-to-space) use of VHF bands in which there is no MSS allocation for the relevant use (domestic or international). The Commission may grant a waiver of the Table of Frequency Allocations for non-conforming uses of spectrum when there is little potential for interference into any service authorized under the Table of Frequency Allocations and when the non-conforming operator accepts any interference from authorized services.[78] The reception of transmissions, AIS or other, cannot cause harmful interference, and these transmissions will be present pursuant to existing authorizations using frequencies allocated to other services regardless of whether they are received by an Iridium second-generation satellite. Further, we conclude that the service Iridium proposes, with its partner Harris Corporation, will serve the public interest by increasing maritime domain awareness for both government and commercial users. Accordingly, we waive sections 2.102(a) and 2.106. As a condition of this waiver, Iridium must not claim protection for reception of messages in the 156.0125-162.0375 MHz band that is not in accordance with the Table of Frequency Allocations for the pertinent area, and may only claim protection to the extent provided by the status of the reception under the Table of Frequency Allocations. In addition, we note that all reception in this band must comport with the requirements on unauthorized publication or use of communications in section 705 of the Communications Act of 1934, as amended.[79]

22. In addition, we waive section 25.112(a)(3) to permit consideration of Iridium's request for operations on the channels 161.950 MHz (ASM 1), 162.000 MHz (ASM 2), 156.525 MHz (DSC-R), and 156.8 MHz (maritime mobile distress), which are not allocated internationally for the MSS. In 2003, the Commission determined to return as "premature" such applications seeking to operate in frequencies for which there is no international allocation, because it can take several years for the ITU to adopt an international frequency allocation.[80] The Commission also expressed concern that such applications would constitute "place holders." In this case, however, the lack of a current MSS allocation in these bands does not necessarily preclude initiation of service, as transmissions may be conducted under other

[73] 47 C.F.R. § 1.3.

[74] *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

[75] *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969), *cert. denied*, 409 U.S. 1027 (1972); *Northeast Cellular*, 897 F.2d at 1166.

[76] *NetworkIP, LLC v. FCC*, 548 F.3d 116, 125-28 (D.C. Cir. 2008); *Northeast Cellular*, 897 F.2d at 1166.

[77] Section 2.102(a) is a companion to section 2.106, and states that the assignment and "actual use" of radio frequencies between 9 kHz and 275 GHz shall be in accordance with the Table of Frequency Allocations in section 2.106, except as otherwise provided in other paragraphs of section 2.102. Waiver of section 2.102(a) is necessary to authorize Iridium's requested operations that are not in conformance with the Table of Frequency Allocations.

[78] *See, e.g., Applications by Orbcomm License Corp. For Authority to Modify its Non-Voice, Non-Geostationary Satellite System et al.*, Order and Authorization, 23 FCC Rcd 4804, 4809, para. 15 (IB/OET 2008), https://apps.fcc.gov/edocs_public/attachmatch/DA-08-633A1.pdf.

[79] 47 U.S.C. § 605.

[80] *Space Station Licensing Reform Order*, 18 FCC Rcd at 10783, para. 49, 10809, para. 124.

allocations. Accordingly, we do not believe it would serve the public interest to prohibit Iridium the flexibility of including the capability to receive messages in the VHF receiver also on frequencies not allocated to the MSS.

23. In addition, we have examined the technical information regarding the VHF receiver and agree with Iridium that application of section 25.210(f) and (i) as default service rules are inappropriate in this instance. We waive section 25.217(b) and these requirements accordingly.[81] Because section 25.287 contains requirements on earth stations, it is inapplicable to Iridium's request for a space station authorization.

C. Automatic Dependent Surveillance–Broadcast Receiver

24. Iridium also proposes to include a 1090 MHz Extended Squitter ADS-B receiver on its second-generation satellites. ADS-B is a service in which a transmitter periodically broadcasts information from and about an aircraft. The information may include the aircraft's identity, current position, altitude, and velocity, and it is broadcast to other ADS-B equipped aircraft and ADS-B ground stations, for distribution to air traffic control systems.[82] Iridium's proposed space-based reception of this information would allow aircraft to communicate ADS-B information to air traffic control systems while in areas where there are no ADS-B ground stations in view of the aircraft.

25. The 1090 MHz Extended Squitter[83] broadcast link is used internationally for ADS-B services.[84] The frequency band used for ADS-B, 1087.7-1092.3 MHz, was recently allocated internationally to the AMS(R)S (Earth-to-space) on a primary basis, limited to space station reception of ADS-B emissions from aircraft transmitters that operate in accordance with recognized international aeronautical standards.[85] The U.S. Table of Frequency Allocations does not yet include this allocation.

26. Iridium states that it plans for the ADS-B payload to be authorized by another administration, but has not provided additional information on the status of any such authorization. Lacking any additional information on the identity of the proposed authorizing authority, or on the status of any pending application, we conditionally authorize Iridium operations using the 1087.7-1092.3 MHz frequency band. As with the reception of AIS messages, we find good cause to waive sections 2.102(a) and 2.106 to permit reception of ADS-B messages on an unprotected basis in the United States because doing so will not cause any interference or unreasonably preclude other services. Any future protection of ADS-B reception will be governed by the relevant status in the Table of Frequency Allocations and must be in accordance with any subsequent rulemaking proceedings to implement any new domestic allocations or service rules.

27. In response to the concern expressed by Inmarsat, we clarify that the reception of ADS-B

[81] We address below Iridium's requests for waivers of the milestone requirements in section 25.164 and the bond-posting requirement in section 25.165.

[82] *See* 47 C.F.R. § 87.5 (defining ADS-B Service). Specifically, ADS-B messages are produced by "ADS-B Out." *See* 14 C.F.R. § 91.227(a) (defining ADS-B Out); *Automatic Dependent Surveillance-Broadcast (ADS-B) Out Performance Requirements To Support Air Traffic Control (ATC) Service*, Docket No. FAA-2007-29305, 75 FR 30160, 30161-62 (May 28, 2010) (*ADS-B Out Rule*); *see also* 14 C.F.R. § 91.227(d) (required contents of ADS-B Out message). ADS-B is an important component of the Federal Aviation Administration's Next Generation Air Transportation System. *See generally ADS-B Out Rule*.

[83] The extended squitter is a long message transmitted automatically, without needing to be interrogated by radar, to announce the aircraft's presence to nearby ADS–B equipped aircraft or ground-based air traffic control. *ADS-B Out Rule*, 75 FR at 30162 n.6.

[84] *Id.*, 75 FR at 30163.

[85] 2015 World Radiocommunication Conference, Final Acts at 19 (adding footnote 5.328AA to the 960-1164 MHz allocations), http://www.itu.int/pub/R-ACT-WRC.12-2015/en. The new international allocation will come into force on January 1, 2017. *Id.* at 73 (adding No. 59.13 to the ITU Radio Regulations).

or AIS messages on Iridium satellites, and relaying of that information through Iridium feeder links, does not alter the rights and obligations of the relevant parties with respect to coordination and protection of Iridium feeder links.[86] We also find that Iridium has provided sufficient information regarding its proposed 1090 MHz Extended Squitter ADS-B receiver to process its application.

D. Protection of Radio Astronomy

28. Iridium's use of the 1617.775-1626.5 MHz band is constrained by section 25.213[87] and footnote 5.372 of the Table of Frequency Allocations,[88] which require protection of stations in the radio astronomy service (RAS) operating in the 1610.6-1613.8 MHz band. In particular, ITU Resolution 739, as revised by WRC-15, addresses the compatibility between the radio astronomy service and satellite services in several frequency bands including the 1610.6-1613.8 MHz band.

29. Iridium initially proposed to meet these obligations by employing a series of configuration changes on its second-generation satellites during RAS collection events.[89] CRAF and NRAO, representing radio astronomers from Europe and the United States, respectively, objected to the protection levels and coordination required by Iridium's initial proposal. Subsequently, Iridium developed a new plan. Iridium now proposes to shift traffic from satellites in view of RAS sites onto adjacent satellites, thereby limiting spurious emissions into the RAS band. Iridium states that, using this method, it will be able to meet the 2 percent data loss criteria recommended by the ITU for the protection of the RAS.[90]

30. We believe that Iridium's proposal, if successfully implemented, will be sufficient to protect observations of the RAS. We note, however, that Iridium will remain obliged in section 25.213 to take "whatever steps necessary" to avoid causing harmful interference from its downlink operations into the U.S. RAS sites listed in section 25.213 during periods of observation. In addition, we believe that it is appropriate to require that all Iridium operations be subject to the terms of the ITU Radio Regulations.

E. Technical Waivers

31. *Cross-Polarization Isolation.* Iridium requests waiver of section 25.210(i)(1), which requires that space station antennas in the FSS, other than those in the 17/24 GHz Broadcasting-Satellite Service, be designed to provide a cross-polarization isolation of at least 30 dB within their primary coverage area.[91] This rule applies to Iridium's feeder-link and TT&C operations in Ka-band frequencies allocated to the FSS. Iridium states that its second-generation satellites are designed to use feeder-link beams with a cross-polarization isolation of 19 dB and TT&C beams with a cross-polarization isolation of

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[86] *See Inmarsat Mobile Networks, Inc. Application to Operate a Fixed-Satellite Service Gateway Earth Station Facility in Lino Lakes, Minnesota with the Inmarsat-5 F2 Space Station*, Order and Authorization and Declaratory Ruling, 30 FCC Rcd 2770 (IB/OET 2015), https://apps.fcc.gov/edocs_public/attachmatch/DA-15-392A1_Rcd.pdf.

[87] 47 C.F.R. § 25.213; *see also Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610–1626.5/2483.5–2500 MHz Frequency Bands*, Report and Order, 9 FCC Rcd 5936, 5976-82, 6043-46 (1994) (adopting section 25.213), https://apps.fcc.gov/edocs_public/attachmatch/FCC-94-261A1.pdf.

[88] 47 C.F.R. § 2.106, footnote 5.372; *see also Spectrum and Service Rules for Ancillary Terrestrial Components in the 1.6/2.4 GHz Big LEO Bands; Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands*, Second Order on Reconsideration, Second Report and Order, and Notice of Proposed Rulemaking, 22 FCC Rcd 19733, 19742, para. 20 (2007), https://apps.fcc.gov/edocs_public/attachmatch/FCC-07-194A1.pdf; *First Generation License*, para. 14.

[89] Second Generation Application, Engineering Statement at 41-44.

[90] Letter from Scott Blake Harris, Counsel to Iridium Constellation LLC, to Jose Albuquerque, Chief, Satellite Division, International Bureau, FCC, at 2 (filed Mar. 28, 2016) (included here as Appendix B).

[91] 47 C.F.R. § 25.210(i)(1); Second Generation Application, Narrative at 12-13, Engineering Statement at 21-23.

15 dB.[92] In support of its waiver request, Iridium states that the cross-polarization isolation for the second-generation satellite feeder-link beams is the same cross-polarization isolation used for the currently operating satellites.

32. Inmarsat and ViaSat oppose a waiver of section 25.210(i)(1), arguing that Iridium's failure to meet the cross-polarization isolation requirement may make sharing with GSO FSS operations in the 29.25-29.3 GHz band more difficult.[93] SES does not oppose grant of the waiver, but asks that an appropriate condition be placed to protect future, compliant space stations.[94]

33. We grant Iridium waiver of section 25.210(i)(1). In the *Part 25 Second Report and Order*, the Commission deleted this requirement as unnecessary.[95] While the revised rules have not yet come into effect, we do not find a public interest benefit in requiring Iridium to meet a technical obligation the Commission has determined is unnecessary. Accordingly, we waive section 25.210(i)(1), and decline to impose the conditions requested by SES.

34. *Mid-Band TT&C.* Iridium also requests waiver of section 25.202(g) to allow TT&C operations throughout its assigned Ka-band feeder-link frequencies.[96] Section 25.202(g) requires TT&C functions to be conducted "at either or both edges of the allocated band(s)."[97] The purpose of the rule is to simplify the coordination process for satellite systems, to provide an incentive for the operator to maximize the efficiency of its system's TT&C operations, and to minimize the constraints placed on other satellite operations.[98]

35. Iridium second-generation satellites are designed to perform band-edge TT&C operations using omnidirectional antennas on center frequencies of 29.102 GHz, 29.298 GHz, and within 19.4022-19.4062 GHz when the satellites are in view of Iridium's feeder-link earth station network. In addition, Iridium plans to embed TT&C information into its normal Ka-band feeder-link operations and transmit that information between satellites using its inter-satellite links. Iridium states that this approach allows it to maintain connectivity in real time with every satellite in its constellation, and is a feature of its existing constellation. Iridium also states that its coordination agreements contemplate this TT&C use. SES does not oppose grant of the waiver, but asks that any waiver be accompanied by conditions.[99]

36. We waive section 25.202(g). In the *Part 25 Second Report and Order*, the Commission amended section 25.202(g) to permit mid-band TT&C that does not cause additional interference than, and does not require additional protection than, normal service traffic. In accordance with the Commission's current policy in this regard, we waive section 25.202(g) to permit the requested mid-band operations. Iridium will be required to operate its mid-band TT&C in accordance with the revised

[92] Second Generation Application, Narrative at 12-13, Engineering Statement at 21-22.

[93] Inmarsat Petition at 4-5; Inmarsat Reply at 4-5; ViaSat Response at 2-3.

[94] SES Comments at 2-4; SES Reply at 5-7.

[95] *Part 25 Second Report and Order*, 30 FCC Rcd at 14817 para. 333.

[96] Second Generation Application, Narrative at 15-16, Engineering Statement at 23; *see also* Iridium Opposition at 8-9.

[97] 47 C.F.R. § 25.202(g).

[98] *Amendment of the Commission's Rules with regard to the 3650-3700 MHz Government Transfer Band; The 4.9 GHz Band Transferred from Federal Government Use*, First Report and Order and Second Notice of Proposed Rulemaking, 15 FCC Rcd 20488, 20538-39, para. 129 (2000), https://apps.fcc.gov/edocs_public/attachmatch/FCC-00-363A1.pdf.

[99] SES Comments at 3-4. Specifically, SES asks that we include with any waiver a statement that Iridium's mid-band TT&C operations must conform to existing and future coordination agreements, are permitted solely on an unprotected and non-harmful interference basis, and must accommodate future satellite networks that comply with section 25.202(g).

operational requirement in section 25.202(g). We believe that this treatment more appropriately balances the needs of Iridium and GSO FSS operators than would the strict non-interference condition proposed by SES, which is based on earlier Commission policies.

37. *Stored Energy at End of Life.* Iridium seeks waiver of sections 25.114(d)(14)(ii) and 25.283(c). Specifically, Iridium second-generation satellites operate using a single tank with a usable volume of 220 liters. The tank contains an internal bladder. One side of the bladder membrane is filled with 1.5 kg of nitrogen pressurant and is sealed prior to launch. At end-of-life of a second-generation satellite, the nitrogen "dry" side of the membrane will occupy a volume of approximately 219 liters. After review of the technical information provided by Iridium, we conclude that waiver of section 25.283(c) is warranted with respect to this de minimis inert gas. Iridium also reports that, following fully depleting fuel at end-of-life, on the other side of the membrane it anticipates that up to 1.6 kg of hydrazine will remain in the propellant lines of the system. Iridium has properly disclosed its passivation plans, and therefore waiver of section 25.114(d)(14)(ii) is unnecessary.

38. *Technical Information.* Finally, Iridium requests waiver of section 25.114(c)(4)(vi) and (vii) to the extent necessary.[100] At the time Iridium submitted its Second Generation Application, these rules required space station applicants to provide the gain of transponder channels and the predicted receiver and transmitter channel filter response characteristics. Iridium states that this information is inapplicable to its satellite design, which uses on-board processors and regenerative payloads. We agree, and therefore find that waiver is unnecessary. We note in any event that these information requirements were deleted from our rules.[101]

39. In addition, Iridium requests waiver of section 25.114(c)(4)(vi)(B) to omit the recommended 2 dB, 4 dB, 6 dB, 8 dB, 10 dB, 15 dB and 20 dB antenna gain contours regarding its VHF receiver.[102] We have reviewed the technical information provided by Iridium and conclude that these additional gain contours are unnecessary for this receiver.

F. Other Matters

40. *Processing round, bond and milestones*. As noted above, Iridium seeks to operate using ADS-B and AIS frequencies that are not authorized for its current-generation satellites. This request for NGSO-like satellite operation using additional spectrum is potentially subject to consideration in a processing round under section 25.157, and any resultant grant for such operation is subject to the bond-posting requirement in section 25.165 and satisfaction of a milestone schedule set forth in section 25.164.

41. The Commission may waive any rule for good cause. The purpose of the processing round procedure is to prevent one applicant from unreasonably precluding additional entry by other operators in the requested frequency band.[103] The bond and milestone requirements discourage spectrum warehousing. In this instance, Iridium's receive-only operations in the ADS-B and AIS bands will not preclude any additional satellite operator from receiving the same signals on its own satellite system. ADS-B and AIS messages are transmitted under existing, terrestrial wireless licenses and are not for the exclusive use of Iridium. Such transmissions would occur in most cases with or without the presence of Iridium satellite receivers. In addition, we note that Iridium's new satellites otherwise qualify as replacement satellites, which are not subject to the processing round, bond and milestone requirements

[100] 47 C.F.R. § 25.114(c)(4)(vi), (vii) (2013); Second Generation Application, Narrative at 11-12, Engineering Statement at 30.

[101] *See International Bureau Announces the Effective Date of Rules Adopted in the Part 25 Order*, Public Notice, DA 14-1270 (rel. Sept. 3, 2014), https://apps.fcc.gov/edocs_public/attachmatch/DA-14-1270A1_Rcd.pdf; *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, Report and Order, 28 FCC Rcd 12403, 12431, para. 84 (2013), https://apps.fcc.gov/edocs_public/attachmatch/FCC-13-111A1_Rcd.pdf.

[102] Second Generation Application Amendment, Narrative at 11, Engineering Statement at 4.

[103] *Space Station Licensing Reform Order*, 18 FCC Rcd at 10774-75, para. 25.

indicated above. Rather, the Commission has expressed confidence that requests for replacement satellites will be intended to continue an existing service, rather than being filed for speculative purposes.[104] Here, Iridium's initial second-generation satellites, including additional receive frequencies, are scheduled for imminent launch. Because of the nature of ADS-B and AIS automatic transmitters, inclusion of the additional receive frequencies on replacement satellites, and unconstrained opportunities for additional entry in these services, we find good cause to waive sections 25.157, 25.164, and 25.165 notwithstanding the eventual protection afforded to Iridium receivers on AIS channels 1 and 2, and potentially on additional channels pending future allocations. Other receive operations on an unprotected basis do not raise the potential for warehousing concerns.

42. *License Term*. We modify Iridium's license to specify an extended license term applicable to the second-generation satellites, beginning at 3 a.m. Eastern Time on the date when Iridium notifies the Commission that operation of an initial second-generation space station is compliant with the terms and conditions of this authorization and that the space station has been placed in its authorized orbit, and ending 15 years later.[105] Because Iridium proposes to remove its first-generation satellites from service as they are replaced in orbit by second-generation satellites, those first-generation satellites will remain subject to a license term ending on January 31, 2018.

43. *Ligado Request*. We decline Ligado's informal request to hold in abeyance the Iridium application. The issues Ligado raises in this proceeding are derivative of claims that Iridium has made in IB Dockets 11-109 and 12-340, and are better suited for treatment in those separate proceedings.[106]

IV. CONCLUSION AND ORDERING CLAUSES

44. We conclude that grant of Iridium's application for a second-generation NGSO MSS satellite constellation, as conditioned herein, will serve the public interest, convenience and necessity.

45. Accordingly, IT IS ORDERED that the application of Iridium Constellation LLC, File Nos. SAT-MOD-20131227-00148 and SAT-AMD-20151022-00074, to modify its license for a non-geostationary-satellite orbit, mobile-satellite service and aeronautical mobile-satellite (route) service satellite system IS GRANTED, and Iridium Constellation LLC IS AUTHORIZED to construct, deploy and operate a constellation of 66 space stations at an altitude of 778 kilometers and arranged in six orbital planes, with an inclination of 86.4 degrees. The initial insertion orbit for Iridium second-generation satellites is a 625 km altitude circular orbit with an inclination of 86.66 degrees. Iridium second-generation satellites will utilize the following frequency bands, consistent with the operational parameters and technical specifications in its application:

a. 156.0125-162.0375 MHz (Earth-to-space) for reception of Automatic Identification System, Application Specific Messages, Digital Selective Calling, and maritime distress, urgency and safety calling transmissions from maritime vessels;

b. 1087.7-1092.3 MHz (Earth-to-space) for reception of Automatic Dependent Surveillance–Broadcast transmissions from aircraft;

c. 1617.775-1618.725 MHz (space-to-Earth and Earth-to-space) for mobile-satellite service on a shared basis with the Globalstar system;

d. 1618.725-1626.5 MHz (space-to-Earth and Earth-to-space) for mobile-satellite service on an exclusive basis and for aeronautical mobile-satellite (route) service in oceanic, polar, and remote regions;

[104] *Id.* at 10825, para. 167.

[105] 47 C.F.R. § 25.121(a), (d)(2).

[106] *See, e.g.*, Comments of Iridium Communications, IB Docket Nos. 11-109 and 12-340 (filed May 23, 2016), https://ecfsapi.fcc.gov/file/60002015571.pdf.

e. 19.4-19.6 GHz (space-to-Earth) for feeder downlinks, telemetry, and tracking;

f. 23.18-23.38 GHz for inter-satellite links; and

g. 29.1-29.3 GHz (Earth-to-space) for feeder uplinks, tracking, and command.

46. IT IS FURTHER ORDERED that this authorization for second-generation satellites is subject to conditions established for the Iridium first-generation constellation, as reproduced in Appendix A.

47. IT IS FURTHER ORDERED that Iridium is authorized to construct and deploy up to 15 second-generation in-orbit spare satellites.

48. IT IS FURTHER ORDERED that sections 2.102(a), 2.106, 25.112(a)(3), 25.157, 25.164, 25.165, 25.202(g), 25.210(f), (i), 25.217(b), and 25.283(c) of the Commission's rules, 47 C.F.R. §§ 2.102(a), 2.106, 25.112(a)(3), 25.157, 25.164, 25.165, 25.202(g), 25.210(f), (i), 25.217(b), 25.283(c), are WAIVED to the extent indicated herein.

49. IT IS FURTHER ORDERED that Iridium must provide the Commission with the information required for Advance Publication, Coordination, and Notification of frequency assignment filings, including due diligence information, pursuant to the Radio Regulations of the International Telecommunication Union. No protection from interference caused by radio stations authorized by other Administrations is guaranteed unless ITU procedures are timely completed or, with respect to individual Administrations, coordination agreements are successfully completed. A license for which such procedures have not been completed may be subject to additional terms and conditions required for coordination of the frequency assignments with other Administrations. Further, operations of the Iridium second-generation satellite constellation must be in accordance with the ITU Radio Regulations.

50. IT IS FURTHER ORDERED that, except to the extent waived above for reception in the 156.0125-162.0375 MHz and 1087.7-1092.3 MHz bands, operations of the Iridium second-generation space stations must be in accordance with the Table of Frequency Allocations, 47 C.F.R. § 2.106. Iridium may claim protection for reception in the 156.0125-162.0375 MHz or 1087.7-1092.3 MHz bands only to the extent permitted under the U.S. Table of Frequency Allocations for domestic operations or the ITU Radio Regulations for international operations, as of the time of operation. Operations in the 156.0125-162.0375 MHz and 1087.7-1092.3 MHz bands must be in accordance with any Commission rulemakings subsequent to the release of this Order and Authorization that implement any new domestic allocations or service rules for these bands.

51. IT IS FURTHER ORDERED that Iridium shall implement its plan for the protection of radio astronomy observations in the 1610.6-1613.8 MHz band set forth in its letter of March 28, 2016, attached hereto, with respect to both U.S. and international observations. In this respect, Iridium shall not produce out of band emissions that cause detrimental interference to radio astronomy observations (see Section III of Article 29 of the ITU Radio Regulations) and must comply with No. 5.372 of the ITU Radio Regulations and with 47 C.F.R. § 25.213.

52. IT IS FURTHER ORDERED that the license term for the Iridium second-generation constellation will be fifteen years, beginning at 3 a.m. Eastern Time on the date when Iridium notifies the Commission that operation of an initial second-generation space station is compliant with the terms and conditions of this authorization and that the space station has been placed in its authorized 778-km orbit.

53. IT IS FURTHER ORDERED that the Petition to Dismiss, Deny or Hold in Abeyance filed by Inmarsat Inc. IS DENIED.

54. This Order and Authorization is issued on delegated authority pursuant to sections 0.241 and 0.261 of the Commission's rules, 47 C.F.R. §§ 0.241, 0.261, and is effective upon release.

FEDERAL COMMUNICATIONS COMMISSION

José P. Albuquerque
Chief, Satellite Division
International Bureau

Jamison Prime
Acting Chief, Policy and Rules Division
Office of Engineering and Technology

APPENDIX A

Conditions on Both First-Generation and Second-Generation Authorizations

Aeronautical mobile-satellite (route) service (AMS(R)S): Iridium may provide AMS(R)S in oceanic, polar, and remote regions, subject to the following conditions:

a. AMS(R)S operations must be confined to the 1618.725-1626.5 MHz frequency band.

b. AMS(R)S operations must comply with MSS coordination agreements with other MSS operators, the results of the agreement seeking process under ITU Radio Regulation 9.21, and coordination agreements with operators of radio astronomy observatories.

c. Any additional protection desired for AMS(R)S operations from interference from previously authorized MSS operations in adjacent frequency bands, beyond that afforded by existing arrangements, must be sought through new or modified inter-operator arrangements.

d. In connection with the provision of AMS(R)S to aircraft of any particular country of registry or in any particular airspace, Iridium is obliged to comply with the applicable laws, regulation, rules and licensing procedures of that country and/or the relevant airspace administrator.

e. Iridium must limit AMS(R)S operations outside the United States to the oceanic regions, the Antarctic land mass and adjacent waters, and the remote areas of those territories for which it has successfully completed the agreement seeking process pursuant to ITU Radio Regulation 5.367.

f. Iridium must give priority to AMS(R)S and 911 safety messages, by real-time pre-emption if necessary, over all Iridium message traffic that is not considered safety-related pursuant to a recognized safety service.

Executive Branch Agreement: Iridium's authorizations are conditioned upon compliance by Iridium Holdings LLC, Iridium Carrier Holdings LLC, and GHL Acquisition Corp., and their respective subsidiaries and affiliates, with the commitments and undertakings set forth in the Executive Branch Agreement dated August 17, 2001, included as Appendix A in DA 02-307.[107]

Section 309(h): This station license shall not vest in Iridium any right to operate the stations nor any right in the use of the frequencies designated in the license beyond the term thereof nor in any other manner than authorized herein. Neither the license nor the right granted thereunder shall be assigned or otherwise transferred in violation of 47 U.S.C. chapter 5. This license shall be subject in terms to the right of use or control conferred by 47 U.S.C. § 606.

[107] https://apps.fcc.gov/edocs_public/attachmatch/DA-02-307A1.pdf.

APPENDIX B

Iridium Plan to Protect Radio Astronomy Observations

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March 28, 2016

Mr. Jose Albuquerque
Chief, Satellite Division
International Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Iridium Constellation LLC; Application for Modification of Non-Geostationary Mobile Satellite Service System Authorization (S2110) To Launch and Operate Replacement Satellites; Call Sign S2110; File No. SAT-MOD-20131227-00148; Iridium Constellation LLC Petition for Rulemaking RM-11697

Dear Mr. Albuquerque:

On April 29, 2015, the National Radio Astronomy Observatory (NRAO) submitted an *ex parte* letter that has been filed in the above-noted dockets. The NRAO letter appears to express the frustration that some radio astronomers have felt arising from the radio frequency challenges presented by the first-generation Iridium system.

Iridium recognizes the importance of radio astronomy observations for scientific research and education, and the sensitivity of the equipment required to make such observations. It also understands the frustrations reflected in the NRAO letter. Thus, its new Iridium NEXT constellation has been designed specifically to address the concerns of the radio astronomy community. As explained below, once Iridium NEXT is fully operational, it will reduce unwanted emissions into the Radio Astronomy Service (RAS) band to the levels that the RAS community has been seeking.

I.

Iridium has always strived to make the most efficient use of spectrum technically possible. Its unique constellation of low-earth orbiting satellites with spot-beam antennas, and its innovative use of time-division duplex (TDD) that re-uses the same frequency band for service uplinks and downlinks, allows Iridium to do more with less spectrum than other systems. Indeed, with only 8.775 MHz of spectrum, Iridium serves over three-quarters of a million users globally. Its original constellation also uses filtering and other techniques to reduce unwanted emissions. However, as the Iridium system has become critical to first responders and others — and as traffic has grown — over the past two decades, the challenge of avoiding interference into the RAS bands has also grown.

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II.

The NRAO letter expressed concern that due to these changed conditions, especially increased use of the Iridium network and changes in how RAS measurements are made, Iridium's previously proposed interference protection mechanisms for RAS were insufficient. To address this concern, Iridium has developed new, technically sophisticated solutions that will satisfy the needs of the RAS community.

Specifically, Iridium NEXT will improve the interference environment for RAS in three ways:

1) Improved hardware to improve linearity and filtering in the transmission stages

Through the specification of more linear high-power amplifiers (HPAs) and output noise filters, the new design will reduce the unwanted emissions into the RAS band by about 15dB compared to each satellite in the original constellation.

2) Improved traffic and satellite resource management controls

By managing traffic more closely and distributing it more efficiently across the available beams and satellites, it is possible to reduce unwanted emissions further. The beams of Iridium satellites converge as the satellites approach the poles. As a result, and as illustrated below, improved load management will allow the Iridium NEXT network selectively and automatically to switch off beams on satellites passing over RAS sites between 30° and 60° North Latitude, transferring traffic from the satellite over the RAS site to adjacent satellites.[1] Switching off beams on satellites in full view of RAS sites in this way results in fewer intermodulation product signals and less out-of-band noise — yielding fewer spurious satellite emissions in the radio astronomy band and protecting RAS sites 24 hours a day. Analysis of simulations of the Iridium NEXT satellite system operating under this beam management approach showed an RAS data loss of 2 percent (which meets the ITU's strict recommendation for protection of RAS) — or even less.

The figure on the left below illustrates the beam laydown of a satellite operating all 48 available beams. By contrast, the figure on the right shows a satellite where only 28 beams are active because the traffic has been transferred to beams on adjacent satellites.

[1] The system is capable of doing the same between 30° and 60° South Latitude, but lighter traffic in this portion of the southern hemisphere makes this unnecessary.

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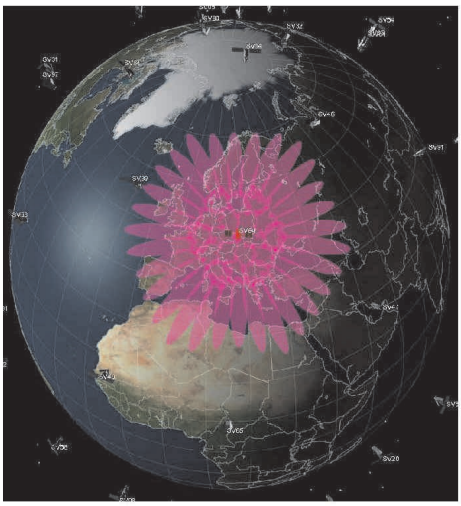

3) New network management software

Iridium NEXT features new network management software that enables Iridium to optimize both the satellite hardware and the traffic distribution to maximize the protection of RAS sites, while maintaining traffic capacity and supporting growth.

III.

Iridium has twice met with the RAS community, under the auspices of the National Science Foundation, to explain that with the three developments noted above, Iridium NEXT can fully protect RAS observatories. Radio astronomers should begin to see a reduction in unwanted emissions in the RAS band at 1610.6-1613.8 MHz due to the improved hardware as soon as the first Iridium NEXT satellites become operational, and this reduction will continue as more and more first-generation Iridium satellites are replaced. By the end of 2017, when the entire Iridium NEXT constellation is scheduled to be operational and the traffic management software features activated, unwanted emissions will be reduced to the thresholds desired by radio astronomers. Indeed, Iridium hopes that once the system is fully operational, additional software and operational advancements will allow even further reduction of emissions into the RAS band.

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IV.

The Iridium constellation is, by any definition, critical infrastructure for our country. The Iridium network provides vital communications links to the U.S. military, to first responders, to those on the high seas, and to those in remote locations. Iridium provides essential links to the 85 percent of the planet that is unserved by terrestrial networks. And when natural or man-made disaster strikes the other 15 percent of the planet, Iridium is there, no matter where the disaster occurs.

Nevertheless, Iridium also recognizes the importance of radio astronomy to our collective welfare and fully understands the concerns the RAS community had about its original constellation. Accordingly, Iridium NEXT has been designed to address those concerns and, once completely operational, the constellation will reduce emissions into the RAS band to the levels long sought by the RAS community. Moreover, Iridium has committed – and looks forward – to working with the RAS community to conduct measurements of the Iridium NEXT satellites as they are launched and become operational.

Respectfully submitted,

Scott Harris

Scott Blake Harris
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